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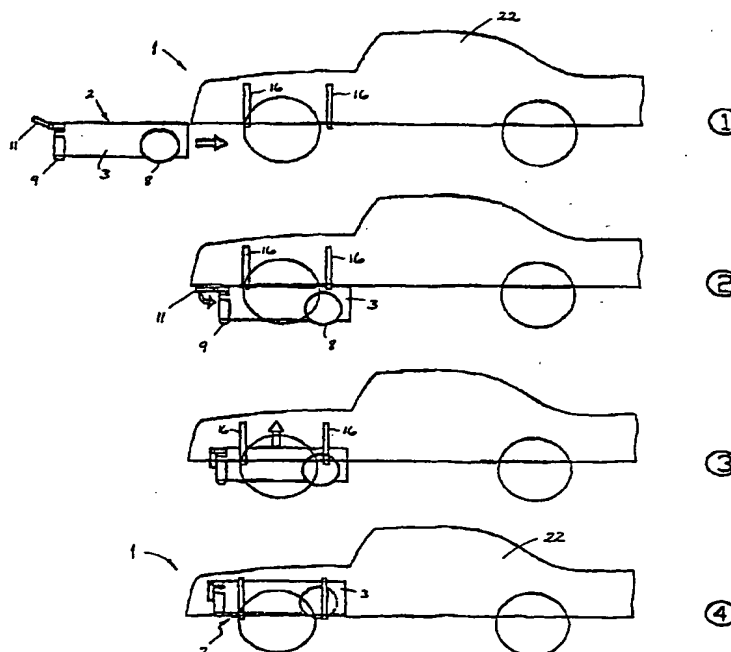
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification 7 : B60S 5/06</p>	<p>A1</p>	<p>(11) International Publication Number: WO 00/58139 (43) International Publication Date: 5 October 2000 (05.10.00)</p>
<p>(21) International Application Number: PCT/SG99/00063 (22) International Filing Date: 30 June 1999 (30.06.99) (30) Priority Data: 9901244-5 25 March 1999 (25.03.99) SG (71) Applicant (for all designated States except US): NANYANG TECHNOLOGICAL UNIVERSITY [SG/SG]; School of Mechanical & Production Engineering, Nanyang Avenue, Singapore 639798 (SG). (72) Inventors; and (75) Inventors/Applicants (for US only): ZHU, Hai, Hong [CN/SG]; Block 130 #06-147, Kim Tian Road, Singapore 160130 (SG). XIE, Ming [SG/SG]; Block 908 #06-209, 91 Jurong West Street, Singapore 640908 (SG). LIM, Mong, King [SG/SG]; 34 Toh Tuck Road #02-05, Good Luck Garden, Singapore 596712 (SG). (74) Agents: HAQ, Murgiana et al.; Haq & Namazie Partnership, Robinson Road, P.O. Box 765, Singapore 901515 (SG).</p>		<p>(81) Designated States: AU, CA, CN, JP, NZ, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report.</p>

(54) Title: BATTERY SYSTEM AND APPARATUS

(57) Abstract

The present invention provides an apparatus (1) for installation and/or removal of a battery pack for an electric vehicle or robot. The apparatus includes a battery pack (2) having a frame (3) for supporting at least one rechargeable battery (4), mobility means (7, 8, 9, 10) provided on the frame (3) enabling the battery pack to traverse or travel over a surface on which the battery pack (2) is located; and lifting means (14, 15) provided on said frame (3) and adapted to raise the battery pack (2) from its position on the surface to an installation position in the vehicle/robot above said surface. The lifting means (14, 15) is also adapted to lower the battery pack from the installation position in the vehicle/robot to a position on the surface. The invention also provides a system for maintaining operative capability in an electric vehicle or robot equipped with an on-board battery pack. The system includes: (i) maintaining a supply of charged battery packs ready for use in the vehicle at a depot at which the vehicle can be received in the course of its operation; (ii) removing a spent or depleted battery pack from the vehicle; (iii) installing one of said charged battery packs from the supply at said depot; and (iv) retaining said spent or depleted battery pack at said depot for recharging and reuse.



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BATTERY SYSTEM AND APPARATUSField of Invention

- 5 The present invention relates to a battery system for maintaining operative capability in an electric vehicle or robot.

The present invention also relates to an installation apparatus for cumbersome and/or heavy articles which need to be raised and/or lowered from their
10 installation position on a regular basis. The apparatus of the invention has particular application to the installation and/or removal of a battery pack for an electric vehicle or robot and will hereinafter be described with reference to this exemplary application. It should be appreciated, however, that the broad concept of the inventive apparatus is not limited to this particular application,
15 but is applicable to a variety of situations where regular installation and/or removal of a heavy or cumbersome article is required.

Background of Invention

- 20 Environmental concerns with issues relating to the production of green-house gases, NO_x and other photo-chemical smog generating compounds, ozone depletion and airborne carbon particulates, are propelling the development of electric vehicles around the world. However, a number of drawbacks or disadvantages still remain with vehicles having an on-vehicle battery re-
25 charging system. Some of these drawbacks are as follows:

- (i) There is an inter-dependence of the battery design and vehicle design processes. That is, the performance, size and life-cycle of the battery will effect the vehicle design. In addition, the daily driving range and space for passengers will constrain the choice of batteries.
- 30 (ii) There are constraints imposed by the batteries' life-cycle. On-vehicle batteries last only for a limited time and have to be replaced periodically at additional cost to the vehicle owner.

(iii) There is a long time delay in the regeneration of electric power. That is, it takes several hours to fully re-charge an on-vehicle battery pack. Generally speaking this waiting time is not acceptable for regular car users.

5 (iv) There is a limited daily driving range without recharge of the on-vehicle battery pack. Without recharging, an electric car will typically travel a distance of only 300 to 400 kilometres. Clearly this is not acceptable for long-distance travelling.

10 (v) There is, or may be, an incompatibility between different charging systems produced by different vehicle manufacturers having different charging principles and/or different connectors. Naturally, also, the differing electricity networks of various countries may require quite distinct charging systems.

(vi) The high cost of a battery pack is a significant part of the total cost of an electric vehicle. As already stated above, on-vehicle battery packs have only a limited life and need to be changed periodically.

15 (vii) There are maintenance and environmental concerns with battery packs. Batteries need to be properly maintained with thermal control, regular over-charging and other maintenance checks. Without such maintenance the batteries themselves may pose a risk to both users and the environment.

20 In view of the above drawbacks there is clearly a need to provide a cheaper, safer and faster battery system for electric vehicles or robots equipped with an on-board battery pack.

Summary of the Invention

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According to one aspect of the present invention there is provided a system for maintaining operative capability in an electric vehicle or robot equipped with an on-board battery pack, the system including:

30 maintaining a supply of charged battery packs ready for use in the vehicle at a depot at which the vehicle can be received in the course of its operation;

removing a spent or depleted battery pack from the vehicle;

installing one of said charged battery packs from the supply at said depot; and

retaining said spent or depleted battery pack at said depot for recharging and reuse.

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In a preferred form of the invention the system includes recharging said spent or depleted battery pack and afterwards adding it to the supply of charged battery packs ready for use at the depot. Preferably, the supply of charged battery packs is maintained under controlled environmental conditions.

10 Preferably also, the system further includes conducting periodic maintenance checks and tests on the depleted and/or charged battery packs.

According to another aspect of the present invention there is provided an apparatus for installation and/or removal of a battery pack for an electric vehicle or robot, the apparatus including:

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a battery pack including a frame for supporting at least one rechargeable battery;

mobility means provided on the frame enabling the battery pack to traverse or travel over a surface, such as the ground, on which the battery pack is located; and

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lifting means provided on the frame and adapted to raise the battery pack from its position on the ground to an installation position in the vehicle/robot above the ground. The lifting means is also adapted to lower the battery pack from the installation position in the vehicle/robot to a position on the ground.

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In a preferred form of the invention the battery pack frame includes a housing for a plurality of rechargeable batteries and for at least one battery charger, and the battery pack includes connectors for the transmission and reception of electrical power to and from the plurality of rechargeable batteries.

30

In a preferred form of the invention the mobility means includes a steerable wheel assembly in engagement with the ground, the wheel assembly being motorised for powered movement of the battery pack. Typically, the wheel assembly includes at least one wheel which is pivotable about a substantially vertical axis to steer the powered movement of the battery pack over the ground surface. The wheel assembly includes at least one wheel which is driven about its rotational axis by an electric motor for powered movement of the battery pack across the ground. Preferably the mobility means includes a manually-operated steering mechanism as well as means for controlling the electric motor which powers or drives the wheel assembly. The manually-operated steering mechanism may include a handle which also incorporates the motor control means.

In a preferred form of the invention the lifting means includes at least one motorised roller adapted to engage with a complementary track extending between the vehicle/robot and the ground. Driven rotation of the roller in engagement with the track causes the roller to travel along the track thereby causing the battery pack to be raised and/or lowered between the installation position and a ground or surface position.

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Preferably the lifting means includes a plurality of motorised rollers, with each roller adapted to engage with its own associated track. The rollers project externally from the sides of the battery pack housing and each is preferably driven via a motor and transmission mechanism within the housing. Each roller preferably includes a toothed wheel, such as a gear or sprocket, which is adapted to mechanically engage with a complementary toothed rack portion of the associated track. Each roller may further include a guide wheel adapted to follow a complementary guiding rail portion of the track. The rack portion and the guiding rail portion of the track are typically arranged parallel and side-by-side each other.

30

Thus, the present invention provides a new system for installation and removal of a battery pack for an electric vehicle. Implementation of this system can enable substantially all of the drawbacks discussed above to be overcome. In particular, the system of the present invention lends itself to a modular design for electric vehicles. That is, the battery pack can be designed as a standard module in all electric cars or vehicles of the same category, standardisation enabling a reduction in overall costs for the vehicle.

By implementing a battery exchange system across an existing network of petrol/gas stations acting as depots, it will be possible to reduce the purchase price for an electric vehicle. The owner of the vehicle would not need to purchase a battery pack. Instead, the battery packs could be obtained on a rental basis from those petrol/gas stations (depots) equipped with a battery exchange system. In this way, when an electric vehicle has depleted or exhausted its battery power supply, the battery pack need simply be removed and a replacement fully-charged battery pack installed. This can be done quickly and simply in only a few minutes using the apparatus of the present invention.

The battery exchange arrangement which becomes practical and desirable with the present invention removes responsibility for service, maintenance and recycling of the vehicle batteries from the vehicle owner and places those functions in the hands of a business competent to ensure that the proper procedures are followed.

25

Brief Description of the Drawings

The above and other features of the present invention will be more apparent from the following detailed description of a preferred embodiment of the apparatus of the invention with reference to the accompanying drawings, in which:

30

Fig. 1 shows perspective front and rear views of a battery pack apparatus according to a preferred embodiment of the invention in an on-ground position;

Fig. 2 is a perspective view of part of the wheel assembly for the apparatus shown in Fig. 1;

Fig. 3 is a detailed perspective view of the lifting means of the apparatus shown in Fig. 1;

Fig. 4 is a perspective view of an apparatus according to a preferred embodiment of the invention showing the battery pack for the electric vehicle or robot lifting itself along tracks to the installation position; and

Fig. 5 is a schematic illustration of apparatus of the invention in use.

Detailed Description of the Preferred Embodiment of the Invention

Referring to Fig. 1 of the drawings, the present invention provides an apparatus (1) for the quick and easy installation and/or removal of a battery pack for an electric vehicle or robot (not shown). The apparatus (1) includes a battery pack (2) having a frame such as a housing (3) for supporting, and in this case enclosing, a plurality of rechargeable batteries (4) together with a battery charger (5). The battery pack (2) includes at least one connector (6) for transmission of electrical power from the batteries to the vehicle during the vehicle's operation, and for reception of electrical power to the batteries when the battery pack (2) is being recharged.

The apparatus further includes mobility means in the form of a steerable ground-engaging wheel assembly (7) provided on the housing (3) enabling the battery pack (2) to traverse or travel over the surface of the ground. The wheel assembly (7) includes a pair of passive wheels (8) connected to an underside of a rear part of the housing (3) and a single powered wheel (9) with associated steering mechanism (10) arranged at a front part of the housing. The front wheel (9) is powered by an electric motor incorporated in the casing of the steering mechanism (10) for powered movement of the battery pack (2) over

the ground surface. The wheel (9) is also manually pivotable by the mechanism (10) about a substantially vertical axis for steering that powered movement of the battery pack. The steering mechanism (10) includes a handle (11) arranged on a column (12) for manually pivoting the wheel (9) to alter the course travelled by the battery pack over the ground surface. Motor control means (13) is also provided for controlling the motor which powers or drives the wheel (9). That control mechanism is conveniently provided on the handle (11) of the manually operable steering mechanism (10) for hand operation by the user. It will be appreciated that in an alternative form of the invention the steering mechanism could be remotely or automatically controlled, as could the motor which powers the wheel assembly (7).

Referring now to Fig. 3 of the drawings, the apparatus (1) of the invention further includes lifting means provided on the frame or housing of the battery pack for both (i) raising the battery pack from its position on the ground to an installation position in the vehicle/robot (i.e. above ground), and (ii) lowering the battery pack from its installation position in the vehicle/robot to a position on the ground surface. The lifting means includes four rollers (14) which project externally of the battery pack housing (3), with two of the rollers (14) spaced apart on opposite sides of the housing. Each of the rollers (14) is driven via a motor (not shown) inside the battery pack housing (3) and via a transmission mechanism (15). The apparatus (1) of the present invention further includes a set of tracks (16) with a respective one of which each of the rollers (14) is adapted to engage. The tracks are typically connected to the vehicle. That is, each of the rollers (14) is associated with a complementary track (16) which extends between the electric vehicle and the surface of the ground. When the rollers (14) are in engagement with the tracks (16), driven rotation of the rollers causes them to travel along the tracks thereby causing the battery pack to be raised and/or lowered between the installation position and a position on the ground surface.

Each of the rollers (14) includes a toothed wheel (17), such as a gear or sprocket, which is adapted to mechanically engage with a complementary toothed rack portion (18) of the associated track (16). Furthermore, each roller (14) also includes a guide wheel (19) adapted to follow a complementary guiding rail portion (20) of the associated track (16) in order to maintain the tooth wheel in proper mechanical engagement with the toothed rack portion. The toothed wheel (17) and the guiding wheel (19) of each roller are arranged side by side and share a common axis of rotation. Correspondingly, the rack portion (18) and the guiding rail portion (20) of each track (16) are arranged side-by-side and parallel to one another. Each of the tracks (16) is preferably in the form of a channel section with the rack portion (18) and the guiding rail portion (20) located within the channel. Each track has an opening (21) for access of the rollers (14) when the battery pack (2) is positioned on the ground.

Fig. 5 of the drawings schematically shows the operation of the apparatus (1) in an electric vehicle (22) adapted for use with an on-board battery pack. The vehicle (22) includes a set of tracks (16) that are connected to it and extend from an installation position for the battery pack (2) in the vehicle towards the ground. Optionally, the tracks (16) themselves may be extendable and retractable. As shown in part 1 of Fig. 5, the battery pack (2) is driven over the ground using the powered wheel assembly (7) which is steered and controlled from the handle (11). The battery pack (2) is driven under the vehicle (22) until the rollers (14) projecting from the housing (3) enter the openings (21) and align with the tracks (16) as shown in part 2. The battery pack (2) may be configured so that folding down of the hinged handle (11) when the rollers (14) are aligned with the tracks actuates the driven rotation of the rollers (14) via the transmission mechanism (15). As shown in parts 3 and 4 of Fig. 5, rotation of the rollers in the tracks (16) causes the battery pack to raise itself off the ground and into the installation position in the vehicle, in which position the battery pack connectors (6) are operatively connected with the vehicle's motor(s). Naturally, this sequence of operation for the apparatus (1) is reversed when the battery pack is to be removed from the vehicle.

The apparatus of the present invention is therefore able to provide a fast and reliable means for replacing the battery pack on-board an electric vehicle or robot in a safe and non-strenuous fashion. The easy operation of the
5 apparatus of the invention enables installation and/or removal of a battery pack to be performed by any able-bodied person, such as the driver of the vehicle themselves.

It will be appreciated that various modifications, alterations and/or additions
10 may be introduced into the construction and arrangement of the parts of the apparatus particularly described herein without departing from the spirit or ambit of the present invention.

CLAIMS

1. An apparatus for installation and/or removal of a battery pack for an electric vehicle or robot, the apparatus including:
 - a battery pack having a frame for supporting at least one rechargeable
5 battery;
 - mobility means provided on the frame enabling the battery pack to traverse or travel over a surface on which the battery pack is located; and
 - lifting means provided on said frame and adapted to raise the battery
pack from its position on the surface to an installation position in the
10 vehicle/robot above said surface, said lifting means also adapted to lower the battery pack from the installation position in the vehicle/robot to a position on the surface.
2. An apparatus as claimed in claim 1 wherein the battery pack frame
15 includes a housing for a plurality of rechargeable batteries and for at least one battery charger, and wherein the battery pack includes connectors for the transmission and reception of electrical power to and from the plurality of rechargeable batteries.
- 20 3. An apparatus as claimed in claim 1 or claim 2 wherein the mobility means includes a steerable wheel assembly in engagement with said surface, said wheel assembly being motorised for powered movement of the battery pack over the surface.
- 25 4. An apparatus as claimed in claim 3 wherein the wheel assembly includes at least one wheel which is pivotable about a substantially vertical axis to steer the powered movement of the battery pack over the surface.
- 30 5. An apparatus as claimed in claim 3 or claim 4 wherein the wheel assembly includes at least one wheel driven about its rotational axis by an electric motor for powered movement of the battery pack across the surface.

6. An apparatus as claimed in claim 4 and claim 5 wherein the at least one pivotable wheel is a driven wheel and is connected to a front part of the battery pack frame, and wherein the wheel assembly includes two passive wheels connected to a rear part of the battery pack frame.
- 5
7. An apparatus as claimed in any one of claims 3 to 6 wherein the mobility means includes a manually-operated steering mechanism and means for controlling the electric motor which powers or drives the wheel assembly, the manually-operated steering mechanism including a handle incorporating the
- 10 motor control means.
8. An apparatus as claimed in any one of the preceding claims wherein the lifting means includes at least one motorised roller adapted to engage with a complementary track extending between the vehicle/robot and said surface,
- 15 wherein driven rotation of the roller in engagement with the track causes the roller to travel along the track thereby causing the battery pack to be raised and/or lowered between the installation position and surface position.
9. An apparatus as claimed in claim 8 wherein the lifting means includes a
- 20 plurality of said motorised rollers.
10. An apparatus as claimed in claim 8 or claim 9 wherein each roller projects externally of the battery pack frame and wherein each roller is adapted to engage with its own associated track.
- 25
11. An apparatus as claimed in any one of claims 8 to 10 wherein each roller includes a toothed wheel, such as a gear or a sprocket, which is adapted to mechanically engage with a toothed rack portion the associated track.
- 30
12. An apparatus as claimed in claim 11 wherein each roller further includes a guide wheel adapted to follow a guiding rail portion of the associated track to maintain the toothed wheel in mechanical engagement with the rack portion.

13. An apparatus as claimed in any one of claims 8 to 12 further including one or more tracks adapted to be mounted on the vehicle or robot to direct the battery pack to the installation position in the vehicle/robot.

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14. An apparatus as claimed in claim 13 wherein each track includes a toothed rack portion and a guiding rail portion arranged substantially parallel side-by-side.

10 15. A system for maintaining operative capability in an electric vehicle or robot equipped with an on-board battery pack, the system including:

maintaining a supply of charged battery packs ready for use in the vehicle at a depot at which the vehicle can be received in the course of its operation;

15 removing a spent or depleted battery pack from the vehicle;

installing one of said charged battery packs from the supply at said depot; and

retaining said spent or depleted battery pack at said depot for recharging and reuse.

20

16. A system as claimed in claim 15 further including:

recharging said spent or depleted battery pack and afterwards adding it to the supply of charged battery packs ready for use at the depot.

25 17. A system as claimed in claim 15 or claim 16 wherein the supply of charged battery packs is maintained under controlled environmental conditions.

18. A system as claimed in any one of claims 15 to 17 further including:

conducting periodic maintenance checks and tests on said depleted
30 and/or charged battery packs.

19. A system as claimed in any one of claims 15 to 18 wherein the system is able to be carried out at each of a plurality of separate depots, at any one of which depots the vehicle can be received in the course of its operation.
- 5 20. A system as claimed in any one of claims 15 to 19 wherein removal of said spent or depleted battery pack from the vehicle and/or installation of said charged battery pack from said supply is performed using an apparatus as claimed in any one of claims 1 to 14.
- 10 21. An electric vehicle adapted for use with an on-board battery pack, said vehicle including an apparatus as claimed in any one of claims 1 to 14.

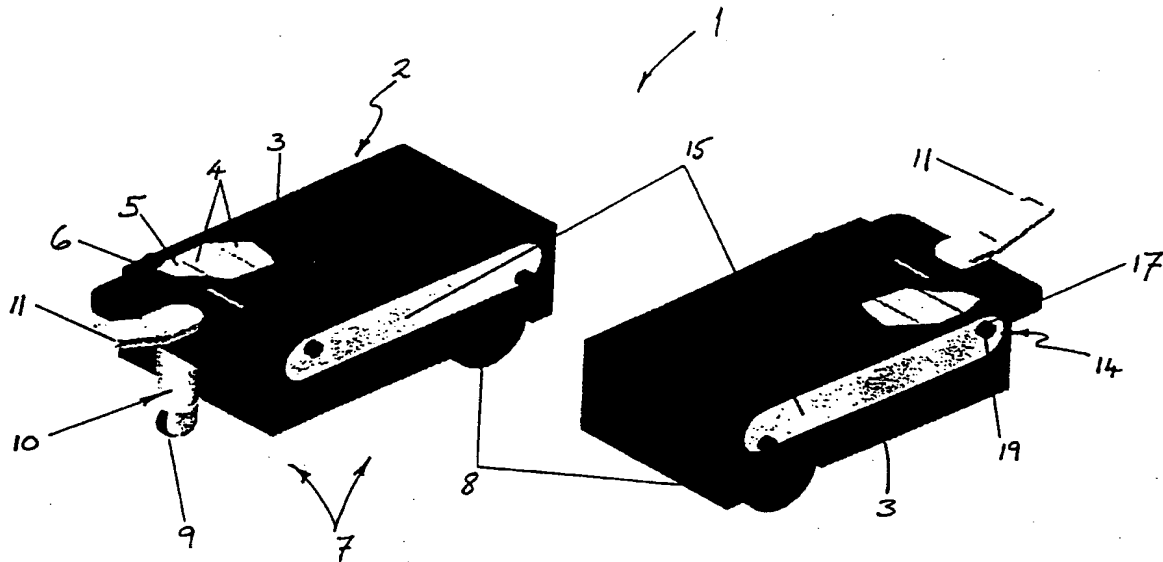


Fig 1

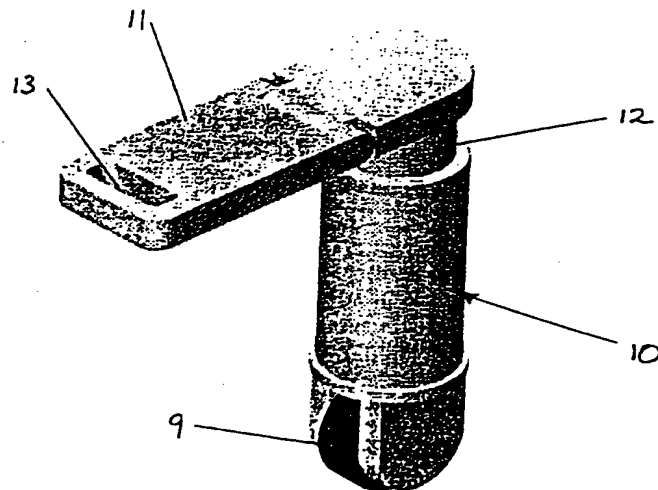


Fig 2

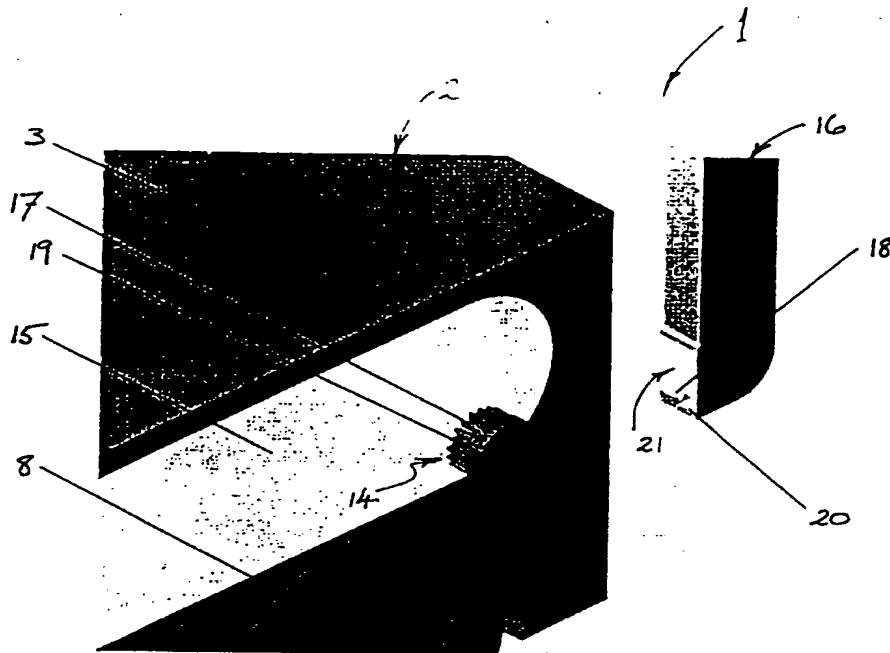


Fig 3

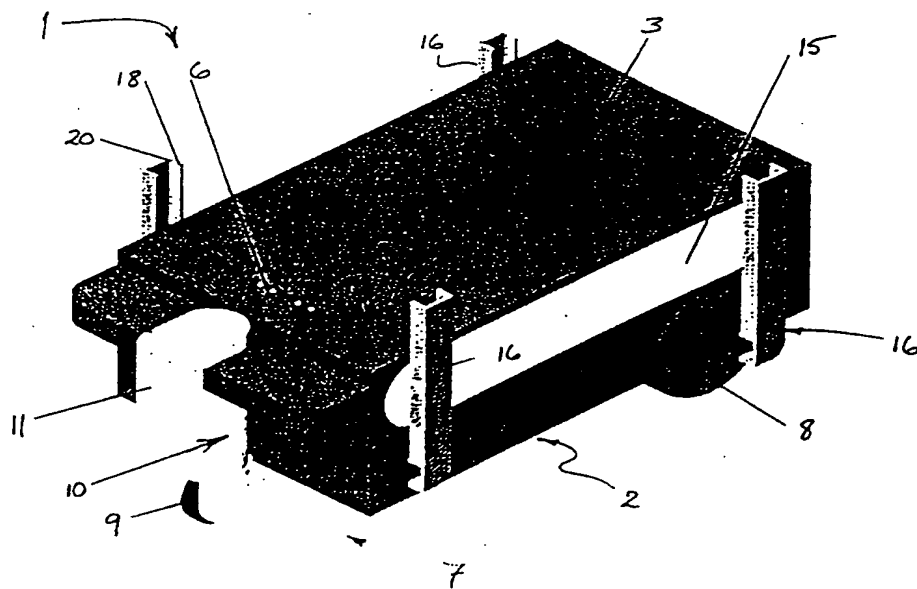
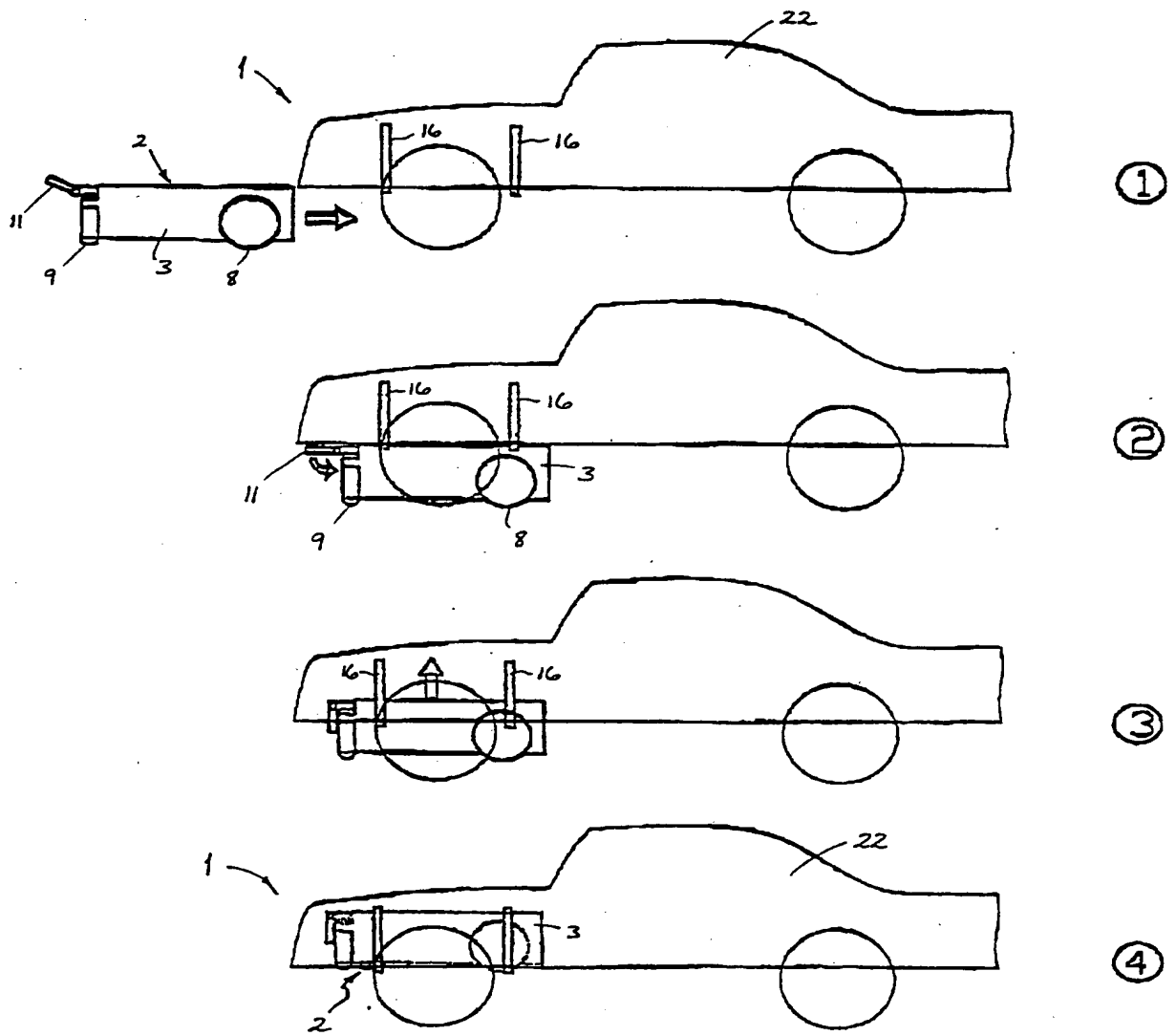


Fig 4

FIG. 5



INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/SG 99/00063

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60S5/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60S A61G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 369 792 A (SUNRISE MEDICAL LTD) 23 May 1990 (1990-05-23)	1,21
Y	column 2, line 28 -column 5, line 51; figures 1-3	20
A	----	2,8
X	US 5 545 967 A (GARLOW DAVID A ET AL) 13 August 1996 (1996-08-13)	15,16,18
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X	WO 82 01349 A (CHLORIDE GROUP LTD) 29 April 1982 (1982-04-29)	1,21
A	page 3, line 17 -page 7, line 22; figures	2
X	DE 42 29 687 A (DIETER KITTO WERKZEUG UND MASC) 10 March 1994 (1994-03-10)	15-17,19
	column 2, line 52 -column 4, line 9; claims; figures	

☐ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

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